

REMARKS

Reconsideration and allowance are respectfully requested in light of the above amendments and the following remarks.

Claims 1-6 and 11-18 stand rejected, under 35 USC §103(a), as being unpatentable over Tanaka et al. (US 6,377,596) in view of Tokunaga et al. (US 5,425,808) and Nakamura et al. (JP 01-234389). Applicant respectfully traverses these rejections.

Claim 1 recites:

A method for forming a single crystalline film comprising the steps of:

forming an amorphous film on a single crystalline substrate,

forming an opening in the amorphous film and thereby exposing a part of a surface of the substrate, and

introducing atomic beams, molecular beams or chemical beams onto the surface of the substrate at their incident angle of not more than 40 degrees with respect to the substrate surface under a reduced atmosphere and thereby selectively and epitaxially growing a single crystalline film on the exposed surface of the substrate.

Tanaka discloses in Figs. 3A-3E that a given nitride film, such as a GaN film, is formed on a substrate made of monocrystal sapphire via an insulator having an opening. The crystal growth technique used to form the nitride film is metal organic chemical vapor deposition (MOCVD) (col. 15, lines 34-36). Therefore, Tanaka discloses only an epitaxial lateral overgrowth (ELO)

technique which is available only through a chemical vapor deposition (CVD) technique.

As mentioned previously, CVD (MOCVD) and molecular beam epitaxy (MBE) are quite different in principle, though both are commonly used as a film forming means. With CVD, raw material gases are supplied non-directionally in a given flow onto a given substrate (or a given underlayer) and thermally reacted on the substrate. For epitaxial growth, therefore, the directionality of the raw material gases is not important. On the other hand, with MBE, an atomic beam or a molecular beam (not raw material gas) is directionally introduced directly onto a given substrate and deposited directly on the substrate without the thermal reaction. For epitaxial growth, therefore, the directionality of the atomic beam or the molecular beam is quite important.

A Declaration attesting to the differences between CVD and MBE is enclosed with this Amendment. This Declaration expressly states that CVD and MBE are not equivalent methods for the epitaxial growth of a single crystal film on a single crystal substrate. Additionally, this Declaration states that a film grown in good condition by one method may not be capable of being grown in such a condition by another method. These statements are provided by an eminent chemical physicist and professor of materials science.

Although Nakamura describes the MBE technique for introducing a molecular ray onto the main surface of a substrate, the incident angle is set within a range of 0-90 degrees. If the molecular ray is introduced beyond this range, it results in the molecular ray being introduced onto the back surface of the substrate. Therefore, a given thin film cannot be formed on the main surface. In other words, Nakamura discloses only a general incident angle usable for the MBE technique.

In addition, with MBE, the incident angle is generally set close to 90 degrees so as to realize vertical epitaxial growth on a substrate. Therefore, the incident angle cannot be set to a low angle (i.e., close to 0 degrees).

In contrast to Nakamura, claim 1 recites that the incident angle of an atomic beam or a molecular beam is set to a low angle, within a range of 40 degrees or below. If the incident angle is set to more than 40 degrees, the lateral epitaxial growth cannot be realized on an amorphous film with an opening, so that a single crystal film of low dislocation density cannot be formed.

In this way, in the MBE technique, the incident angle is critical and, thus, affects the film forming condition. In the present invention of claim 1, the incident angle which is available in the MBE technique is positively employed.

As a result, the present claimed invention is not obvious from the combination of Tanaka, Tokunaga and Nakamura. Therefore, allowance of claim 1 and all claims dependent therefrom is warranted.

Claim 17, which depends from claim 1, recites a single crystalline substrate. Atomic, molecular, or chemical beams are introduced onto the surface of the single crystalline substrate to grow a single crystalline film on the exposed surface of the substrate. Claim 17 further limits claim 1 by reciting that the single crystalline substrate and the atomic, molecular, or chemical beams are of different materials.

Claim 18 also recites the features of: (1) forming the single crystalline film on the surface of the single crystalline substrate and (2) forming the single crystalline substrate and the single crystalline film using different materials. Claim 18 states that the single crystalline film and a surface layer of the single crystalline substrate, upon which the single crystalline film is formed, have different molecular structures and are not alloys of each other.

In rejecting claims 17 and 18, the Office Action states that Tanaka discloses a method of epitaxial lateral overgrowth of monocrystal GaN on a monocrystal sapphire (Al_2O_3) substrate (page 4, penultimate paragraph). Referring to Figs. 3A-3E of Tanaka,

the Office Action states that this method includes forming a patterned amorphous insulating layer on a substrate of single crystalline sapphire and epitaxially growing a nitride semiconductor material up and out of the patterned opening onto the amorphous insulating layer (page 2, 3rd paragraph).

However, Tanaka discloses that the crystal growth technique used to form the nitride semiconductor material is MOCVD (col. 15, lines 34-36). Therefore, Tanaka discloses an ELO technique which is available only through CVD. The Office Action appears to acknowledge this by stating that Tanaka does not disclose the claimed use of MBE as the method of nitride semiconductor growth (page 2, 4th paragraph).

To overcome the teaching deficit of Tanaka, the Office Action cites Tokunaga for disclosing the lateral overgrowth of GaAs on an amorphous SiO₂ or Si₃N₄ film (page 2, last paragraph). Additionally, the Office Action cites Tokunaga for disclosing the equivalence of MBE and CVD for the growth of epitaxial films (page 2, last paragraph).

However, Tokunaga neither expressly nor impliedly states that MBE and CVD are equivalent methods for growing epitaxial films. Instead, Tokunaga discloses depositing a thin film 2 on the whole surface of a substrate 1 according to various film depositing means (e.g., vacuum vapor deposition, sputtering,

plasma discharge, MBE, CVD, etc.) (col. 1, lines 26-33).

Tokunaga does not suggest that vacuum vapor deposition, sputtering, plasma discharge, MBE, and CVD are equivalent film depositing methods, much less equivalent methods of epitaxial growth.

Thus, it is submitted that Tanaka, Tokunaga, and Nakamura, considered alone or in combination, fail to disclose or teach all of the features of claims 17 and 18. Therefore, allowance of claims 17 and 18 is warranted.

New claim 19 depends from claim 18 and recites that the single crystalline film is YBCO and the single crystalline substrate is SrTiO_3 . Support for these features are found in the specification on at least page 15. It is submitted that these features are not taught by the combined references and, therefore, provide an independent basis for the allowance of claim 19.

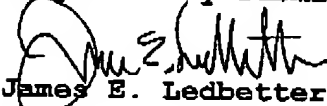
In view of the above, it is submitted that this application is in condition for allowance and a notice to that effect is respectfully solicited.

If any issues remain which may best be resolved through a telephone communication, the Examiner is requested to telephone

the undersigned at the local Washington, D.C. telephone number listed below.

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JEL/DWW/att

Respectfully submitted,


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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of

Inventor: Tatan NISHINAGA Art Unit: 1765
Appln No.: 09/511,912 Examiner: M. Anderson
Filed: February 23, 2000
For: A METHOD FOR FORMING A SINGLE CRYSTALLINE FILM

DECLARATION UNDER 37 CFR 1.132

I, Dr. Avraham Amith, Ph.D. Chemical Physics, Harvard University, 1961; M.A. Physics, Harvard University, 1953; B.S. Chemistry with Honors, University of Michigan, 1951; President of Amtech Engineering Corp.; former COO and General Manager of CERAM-VA Inc.; former Senior Scientific Fellow and Acting Chief Scientist, ITT-Night Vision, ITT; former Member of the Technical Staff, David Sarnoff Research Center, RCA Corp.; former Head of Analysis and Advanced Development Group, RCA Thermoelectric Operations, RCA Corp.; former Adjunct Professor, Department of Materials Science and Engineering, Virginia Polytechnic Institute and State University; former Visiting Professor and Senior Research Scientist in Device Physics, Department of Electrical Engineering, Princeton University; former Senior Scientist and Program Manager, Institute of Energy Conversion, University of Delaware; former Visiting Professor of Physics, Department of Physics, City University of New York Graduate Center & Hunter College; former Member of the Advisory Board, Institute for Nanostructured Materials, Rutgers University; former Associate Editor, Nanostructured Materials (Acta Metallurgica Journal), Pergamon Press; recipient of Phi Beta Kappa, Phi Kappa Phi, and Sigma Xi honors, two teaching awards at Harvard University, Individual RCA Laboratories Outstanding Research Achievement Award, ITT's Worldwide Corporate Gold Quality Team Award, eight U.S. patents, and two foreign patents; and author or co-author of 43 publications,

HEREBY DECLARE that:

Chemical vapor deposition (CVD) and molecular beam epitaxy (MBE) are not equivalent methods for the epitaxial growth of a single crystal film on a single crystal substrate. They are different in principle and in application. In the CVD method,

constituent gases of volatile compounds of the intended film's constituents are introduced into the chamber containing the substrate. This is done under a moderate vacuum, and as the gases reach the substrate, they react chemically thereat, to form the desired film's composition. Epitaxial growth is neither implied nor necessary in the generic CVD method. The application of CVD to epitaxial growth is designated by the name of vapor phase epitaxy (VPE). In other words, VPE is a subset of CVD.

In the MBE method, molecular or atomic constituents are transported directly, as beams, from heated effusion cells into the chamber containing the single crystal substrate. This is done under ultra-high vacuum, and as the components reach the heated substrate (in a highly directional manner), they form the desired compound in a single crystal film. It is a slow process.

The sputtering method differs both from CVD and from MBE. It is a physical deposition process, carried out at a 'poor' vacuum under conditions of glow discharge. It depends on knocking out atoms from a target plate, and having them fly to the substrate plate. Sputtering is the least pristine of the three methods, and is not used for high quality single crystal films.

In summary, the three methods are not equivalent, are not interchangeable, and may not be substituted for one another automatically. A film grown in the requisite good condition (of perfect crystallinity and freedom from various defects) by one method may or may not be capable of being grown in such a condition by the other methods.

I, the undersigned, hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Avraham Amith, Ph.D. 12-10-02
Avraham Amith, Ph.D. Date